SECTION 1

INTRODUCTION AND SPECIFICATIONS

1.1 INTRODUCTION

This instruction manual contains information on the installation, operation, calibration, and maintenance of all power test systems that use the 4500FX.

1.2 GENERAL DESCRIPTION

The 4500FX is a high efficiency power source that provides a low distortion voltage and current output. Three 4500FX Power Sources can be configured as a three-phase power test system. The 4500FX is available with a 20 or 200 amp maximum output for the current output. Both versions have a 270 volt output.

1.3 ACCESSORY EQUIPMENT/RACK SLIDES

General Devices CTS-120-B307-2 rack slides may be attached to the sides of the power source using 8-32 X 3/8 flat head screws.

1.4 SPECIFICATIONS

Table 1-1 contains the operation specifications of both the AC Power Source and the AC Power Test System. All specifications are tested in accordance with standard California Instruments test procedures. The following specifications apply for operation at 100% of full scale voltage, constant line voltages and under no-load and with External Sense Lines connected unless specified otherwise.

Figure 1-1 California Instruments Model 4500FX

TABLE 1-1

4500FX TEST SYSTEM SPECIFICATION

(All specifications apply using external voltage sense, 23 ±5°C, constant line and load conditions unless specified otherwise after 30 minute warm-up)

ELECTRICAL

Input (Nominal line voltage, 60 Hz unless specified otherwise)

Line Voltage: 3 - Phase, 187 - 252 V_{L-L}

Line Current: 20 amps

Line Frequency: 47 to 440 Hz

Efficiency: 75%

Power Factor: 0.7

Line Inrush Current: 178 amps

Isolation	Input to chassis (Neutral to chassis):	50 VRMS
	Input to output:	500 VRMS

Voltage Output (Full to 1/2 voltage range, 23 ±5°C, constant line and load, with external sense, after 30 minute warm-up, unless specified otherwise)

* Power: 1500 VA at 270 volts (312 HV Option)

Power Factor: 0 to 1

* Range: 5 to 270 volts (312 HV Option)

Current: 5.56 amps from 135 to 270 volts.
4.8 amps from 156 to 312 for HV Option.
linearly derate from full current at 1/2 of full-scale voltage to 0.5 amps at 5.0 volts.

Repetitive Peak Current: 13.9 amps RMS (12 amps for HV Option)

Non-Repetitive Peak Current (10ms): 15 amps RMS (13 amps HV Option)

* Total Harmonic Distortion With Linear Load: 0.5% typical
(harmonics and noise to 80 KHz) 1% max

Output Noise (20 KHz to 1 MHz): 200 millivolts RMS.

Line Regulation (10% Line change): 0.02% of range.

* Load Regulation (No-load to Full-load): 0.05% of range.

NOTE (*): Warranted specification. All other specifications are typical.

Voltage Output (continued)

* Frequency Range: 47 to 66 Hz

* Voltage Program Accuracy (No-Load)
  5 to 135 volts: ±0.135 volts
  135 to 312 volts: ±0.54 volts.

Voltage Temperature Coefficient: ±0.02 volts per °C.

Voltage Stability (24 Hrs): ±0.04 volts

Isolation Voltage (output to chassis): 500 volts RMS

Current Output (Full to 10% of current range, 23 ±5°C, constant line and load, with 30 minute warm-up)

* Power: 1500 VA at 200 amps
  500 VA at 20 amps
  400 VA at 2 amps

Power Factor: 0 to 1

* Current Range, Resolution, Accuracy, Compliance Voltage:

RANGE	RESOLUTION	ACCURACY (no-load, shorted output)	COMPLIANCE VOLTAGE
0.02 to 2 amps	0.001	±0.016 amps	200 at 2 amps
2.01 to 20 amps	0.01	±0.16 amps	25 at 20 amps
20.1 to 200 amps	0.1	±1.6 amps	7.5 at 200 amps

* Compliance Voltage: See figure.

* Total Harmonic Distortion with Linear Load: 0.8% typical,
(harmonics and noise to 80 KHz) 1.5% maximum

Output Noise (20 KHz to 1 MHz): 140 ma RMS at 200 amps,
13 ma RMS at 20 amps,
1.5 ma RMS at 2 amps

Line Regulation (for 10% line change): 0.05% of range

* Load Regulation (From no-load to full-load): 0.05% of range.

* Frequency Range: 47 to 66 Hz

NOTE (*): Warranted specification. All other specifications are typical.

Current Output (continued)

Current Temperature Coefficient: ±0.01% of range per °C

Current Stability (24 Hrs): ±0.1 amp for 200 amp range
±0.01 amp for 20 amp range
±0.001 amp for 2 amp range

Isolation Voltage (output to chassis): 500 volts RMS

PROTECTION

Output Overcurrent on Voltage Output: All outputs, voltage and current default to initial conditions.

Output Overvoltage on Current Output: All outputs default to initial values.

Output Short Circuit on voltage Output: All outputs default to initial values.

Output Open Circuit on Current Output: All outputs default to initial values.

Sense Line Open/Short/Reversal: All outputs default to initial values.

Input Overcurrent: Circuit breaker trips.

Input Overvoltage/Transients: Circuit breaker trips for models with standard input line.

Overtemperature: All outputs, voltage and current default to initial conditions.

Incorrect Signal Frequency: Error message on display and

GPIB.

MEASUREMENTS (23 ±5°C, Front Panel and Remote)

	Range	Resolution	Accuracy
*Voltage	0 to 312	0.1 volt	±1.0 volt
*Current	0.02 to 2	0.001 amp	±0.01 amp
	2.01 to 20	0.01 amp	±0.1 amp
	20.1 to 200	0.1 amp	±1.0 amp
*Power	0 to 0.5400 (.624)	0.0002 KW	±0.002 KW
	0 to 5.400 (6.24)	0.002 KW	±0.02 KW
	0 to 54.00 (62.4)	0.02 KW	±0.2 KW
*Frequency	47 to 66	0.01 Hz	±0.02 Hz
*Phase	0 to 359.9	0.1°	±5°

Values in () for HV Option.

Computer Readback: Voltage, Current, Power, Frequency, (programmed and measured values)

CONTROL
Front Panel Control

Keypad: 20-key keyboard

Display: 32 character LCD display

Indicators: Analog voltmeter, Output Overload, Overtemperature, Power-On

Remote Control

Bus: IEEE-488

Subsets: SH1, AH1, T6, L3, SR1, DC1, DT1

Codes and Formats: NR1, HR1, SR1

Data Rate: 200K bytes per second

*Functions

	Initial	Range	Resolution	Accuracy
Voltage	.0 volts	5 to 135	0.01 volt	±0.135 volt
		135 to 270	0.01 volt	±0.54 volt
		(312 for HV Option)		
Frequency	60 Hz	47 to 66	0.01 Hz	±0.001%

Phase Angle (Current is relative to Voltage, Phase B & C Source Voltage relative to Phase A Source Voltage)

	Initial	Range	Resolution	Accuracy
Current	0.0	0 to ±999	0.35 degree	±1 degree
Voltage	120=ØC 240=ØB	0 to ±999	0.35 degree	±1 degree

Current	0.02 amps	0.02 to 2	0.001 amp	±0.016 amp
		2.01 to 20	0.01 amp	±0.16 amp
		20.1 to 200	0.1 amp	±1.6 amps

CALIBRATION: Front panel/Remote calibration of output voltage, output current, output phase angle, measured voltage, measured current and measured simulated power.

OPTIONS:

342 to 456 V_{L-L} 3-phase input voltage
Current with 20 amp maximum output
HV for 312 volt Output Voltage Range

SYSTEM: 3-Phase with 3 power sources

For a 3-phase system, the clock & lock scheme is used for the Phase B and C output. When the slave B and C sources are programmed to external clock mode, they will assume a 240° and 120° phase relationship, relative to the Phase A source output. The Phase B and C sources will power-up in the external clock mode with the phase of the voltage source output set to 240 and 120°, respectively, relative to the Phase A output. The Phase B and C sources can be programmed to the internal clock mode for testing without a Phase A master power source.

MECHANICAL:

Dimensions
Width: 19 inches (48.3 cm)
Height: 10.5 inches (26.6 cm)
Depth: 23.1 inches (58.7 cm)

Weight: 165 pounds (75.2 kg)

Material: Aluminum for Front Panel, rear panel and top cover. Steel for chassis

Finish:
Front Panel - painted gray 26440 per Federal Standard 595
Chassis - zinc plate type 2 class 2
Rear panel and top cover - iridite

Air Intake/Exhaust: Intake at the sides. Exhaust at the rear.

Modularity: Controller, All amplifiers, DC power supplies, Current Limit assembly, Range/Relay Board, All displays

Connectors
Input: Kulka terminal block, 9-85-5 (TB3)

Voltage Output: Kulka terminal block, 9-85-4 (TB1)

20 amp and 2 amp output: shared with Voltage Output (TB1)

200 amp output: Two bus bars (each bus bar has a 3/8" hole for connection)

When the current is programmed from 0.020 to 20.00, the output is available from TB1. When the current is programmed above 20.00 amps the output is available from bus bars.

External Voltage Sense: Amp connector, 1-480705-0 (J6)

IEEE-488 connector: J5

Chassis Slides; Zero Manufacturing Company Model CTN-1-20-E94

ENVIRONMENTAL

Operating Temperature: 0°C to 50°C

Storage Temperature: -40°C to +85°C

Operating Altitude: 0 to 6000 ft.

SECTION 2

INSTALLATION AND ACCEPTANCE

2.1 UNPACKING

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. DO NOT return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment.

2.2 POWER REQUIREMENTS

The AC Power Test System has been designed to operate from a three-phase AC line voltage. The input line voltage may be between 187 volts and 252 volts line-to-line for the standard product. An option is available for 342 to 456 volts line-to-line. The frequency may be between 47 Hz and 440 Hz. Select an AC input line and hookup wire to the AC Power Test System that will deliver 20 amps per phase and still supply a minimum of 187 volts line-to-line. Refer to Figure 2-2 for circuit breaker requirements of the multichassis power test system.

2.3 MECHANICAL INSTALLATION

Each power source has been designed for rack mounting in a standard 19 inch rack. The unit should be supported from the sides with optional rack slides. See Accessory Equipment/Rack Slides in paragraph 1.3. The cooling fan at the rear of the unit must be free of any obstructions which would interfere with the flow of air. A 2.5 inch clearance should be maintained between the rear of the unit and the rear panel of the mounting cabinet. Also, the air intake holes on the sides of the power source must not be obstructed. See Figure 1-1.

2.4 INPUT WIRING

The AC Power Test System must be operated from a three-wire three-phase service with a fourth wire for common. The common wire is connected to the chassis of each AC Power Source. The mains source must have a current rating greater than or equal to the AC Power Source circuit breaker, 20 amps. Refer to Figure 2-1 for the input power connections. Refer to Figure 2-2 for the connections of all power test systems.

2.5 OUTPUT CONNECTIONS

All output connections are at the rear panel of the power source. The outputs are available from a variety of terminal blocks and bus bars. Refer to Figure 2-1.

Figure 2-1 Rear Panel Connections

The 200 amp output is available from a pair of bus bars. Connection to the bus bars is made with a 3/8" bolt and associated hardware.

Connection to the voltage output and the 0.02 through 20 amp output is made at terminal block TB1. The external sense input to J6 must be connected to the voltage output. The voltage regulation is maintained at the External Sense point. Refer to Figure 2-2 for all system connections.

WARNING

> Failure to connect the External Sense input will cause a fault condition to exist.
>
> A "VLT FAULT" error message will be generated when the output voltage is programmed above 5.0 volts.

Figure 2-2 is the system interconnect drawing. For a 1-phase system make the connections shown only for Phase A.

CAUTION

> The 20 Amp output on TB-1 at the rear panel has extremely high voltages between terminals 1 and 2 for currents of 2 amps and less. Program 0.0 amps to reduce the output voltage with a high resistance load.

Figure 2-2 Interconnect drawing

2.6 OUTPUT CURRENT RANGES

The output current can be programmed from 0.02 to 200 amps. For current values from 0.02 amps to 20.00 amps, the output is available from TB1. For currents above 20.00 amps the output is available from the bus bars.

CAUTION

When the current output from TB1 is active the high current bus bars are internally shorted to limit the compliance voltage. Likewise, when the output is programmed from the bus bars, the current output from TB1 is shorted. A high voltage (>300 VAC) will exist across terminals 1 and 2 of TB1 with an open circuit.

2.7 FUNCTION TEST

Refer to Figure 2-3 for the test setup.

Perform the following test sequence.

1) Apply the AC line power and turn on the front panel circuit breaker for all sources. No loads should be connected to any of the outputs. No-load for the current output is defined as a shorted output. All current outputs shown in Figure 2-3 should have a short circuit for their load. The shunt should be directly across the output.

2) Verify that the POWER ON lamps are lit.

3) With the front panel keypad of the Phase A source, program the output voltage to 270 volts with the following sequence:

   5 ENT(to select the Voltage screen (VLT))

   270 PRG ENT (to program 270 volts)

4) Verify that the front panel voltmeter indicates approximately 270 volts. The front panel selector switch must be in the Phase A position.

5) Repeat steps 3 and 4 for the Phase B and C power sources. If no voltage can be programmed for the Phase B and C power sources, check the rear panel coaxial

lines to the Phase A power source. Refer to Figure 2-3.

6) Program the Phase A power source to 200 amps with the following key sequence:

   4 ENT(to select the current screen (CUR))

   200 PRG ENT (to program 200 amps)

   Verify the 200 amp output by measuring 0.20000 VAC from the current shunt.

7) To verify the 20 amp output the 0.01 ohm shunt must be used. Program 20 amps with the following key sequence:

   2 0 PRG ENT

   Verify the 20 amp output by measuring 0.20000 VAC from the 0.01 ohm shunt.

8) To verify the 2 amp output the 0.1 ohm shunt must be used. Refer to Figure 2-3. Program 2 amps with the following key sequences:

   2 PRG ENT

   (Note to program a value less than 1 amp a zero (0) must be entered before the decimal point)

   Verify the 2 amp output by measuring 0.20000 VAC from the current shunt.

Figure 2-3 Function Test Setup

SECTION 3

OPERATION

3.1 GENERAL

A single phase 4500FX Power System has a voltage output and a current output. A 3-phase Power Test System has 3 power sources for each of the 3-phase outputs. The Phase A Power Source controls the frequency. Each of the power controllers control the output voltage, current and phase angle for its respective output phase.

The phase angle of the voltage output for Phase B and C sources is programmed relative to the Phase A voltage output. The current output phase angle is programmed relative to the voltage output of the respective phase.

For currents greater than 20.00 amps the output is available from the bus bars at the rear panel. For currents between 0.02 and 20.00 amps the output is available from TB1.

3.2 FRONT PANEL CONTROLS

All front panel controls are shown in Figure 3-1. A voltmeter selector switch is located at the right side of the front panel voltmeter. The three-position switch must be at the left-most position.

A three-pole circuit breaker is on the left side of the front panel. The circuit breaker is used to switch power to the unit. When the circuit breaker is switched ON, the amber indicator lamp above the circuit breaker illuminates.

The front panel has a subpanel with a keypad, remote lamp, LCD display and a viewing angle adjustment. The 20-key keypad allows the power source to be manually programmed at the front panel. The knob labeled VIEW ANGLE may be turned to adjust the contrast of the front panel display. The remote lamp illuminates when the respective phase of the power system has been addressed through the IEEE-488 interface (GPIB).

3.3 FRONT PANEL INDICATORS

A lamp is located just above the input circuit breaker. It illuminates when power is applied and the circuit breaker is on.

An analog voltmeter, that indicates from 0 to 300 volts, shows the

actual voltage of the voltage output. The three-position toggle switch at the right side of the meter must be set at the left-most position.

Figure 3-1 Front Panel Controls and Indicators

An OVERTEMP lamp illuminates when the temperature of the power amplifier heat sinks has surpassed a maximum set level. When the fault is detected, the outputs are disabled and must be reprogrammed after the overtemperature condition has been eliminated.

An OVERLOAD lamp illuminates when the current from the voltage output exceeds the programmed current limit value. The outputs will default to 5.0 volts shortly after the condition occurs.

An LCD digital display shows the numeric value of all programmed output parameters. It also shows all error messages and measured values.

A REMOTE lamp illuminates when the 4500FX has been addressed from the IEEE-488 interface.

3.4 REAR PANEL CONNECTIONS

(Refer to Figure 3-2 for all rear panel connections.)

3.4.1 POWER INPUT

TB3 is the terminal block for the 3-phase input voltage. Terminals 1, 2 and 3 connect to each leg of the 3-phase input. Terminal 5 is the chassis connection which should be connected to the input mains ground.

3.4.2 POWER OUTPUT

TB1 is the output for voltage and current from 0.02 to 20.00 amps. Refer to Table 3-1 for identification of the TB1 terminals. For current values greater than 20.00 the output is available from the bus bars. Refer to Figure 2-2 for the outputs of a 3-phase power system.

TB1	DESCRIPTION
1	20 Amp Output LO
2	20 Amp Output HI
3	Voltage Output LO
4	Voltage Output HI

TABLE 3-1

Figure 3-2 Rear Panel Connections

3.4.3 EXTERNAL SENSE

J6 is the external sense input connector. The external sense input of each power source must be connected to its own voltage output. If the input is not connected, an VLT FAULT error message will be generated. Table 3-2 identifies the pins of connector J6.

J6	DESCRIPTION	
1	EXT Sense HI	Voltage Sense HI
4	EXT Sense HI	Voltage Sense LO

TABLE 3-2

3.4.4 IEEE-488 CONNECTOR

J5 is the IEEE-488 (GPIB) connector for each 4500FX in the AC Power Test System.

3.4.5 SYSTEM INTERFACE

This connector is not used for any 4500FX Power System. Make no connections to any pin on this connector.

3.4.6 CLOCK

J1 is supplied on the rear panel of each 4500FX. This signal is used by California Instruments power controllers to synchronize the frequency of the oscillators in the Phase B and C Power Sources with Phase A.

3.4.7 LOCK

J2 is supplied on the rear panel of each 4500FX. This signal is used by California Instruments power controllers to phase lock the oscillators in the Phase B and C Power Sources with Phase A.

3.5 FRONT PANEL PROGRAMMING

3.5.1 KEYPAD

The front panel keypad is enabled whenever the REMOTE light is not lit. The AC Power Test System may be manually programmed by using the keypad and observing the front panel LCD display.

Figure 3-3 shows the front panel keypad. Table 3-3 lists the key and a brief description. While viewing any Output Parameter screen (Ref. Table 3-4), the screens may be viewed in increasing order by depressing the MON key and in decreasing order by depressing the PRG key. While viewing the Measurement Screens, the MON and PRG keys work in a similar fashion. For example, if the CUR parameter screen is displayed, the VLT screen may be displayed by pressing the MON key one time. The display will be switched back to the CUR screen by pressing the PRG key.

FIGURE 3-3

KEYPAD

KEY	DESCRIPTION
SNW/0	Inputs the value "0" for all output parameters or to select screen "0" when followed by the ENT key.
SQW/1	Inputs the value "1" for all output parameters or to select screen "1" when followed by the ENT key.
INT/2	Inputs the value "2" for all output parameters or to select screen "2" when followed by the ENT key. Also used to select the Internal Synchronize or Internal Clock modes of operation.
EXT/3	Inputs the value "3" for all output parameters or to select screen "3" when followed by the ENT key. Also used to select the External Synchronize or External Clock modes of operation.
4 through 9	Inputs the indicated numeric value for all output parameters or to select the corresponding screen when followed by the ENT key.
MNU/.	Selects the Menu screens that show all display screens and the corresponding numeric value. The decimal point function of this key is enabled after any numeric key is depressed.
A	Used to direct any parameter change to phase A. Also used to update any quantity in the display identified as A=.
B	Used to direct any parameter change to phase B. Also used to update any quantity in the display identified as B=.
C	Used to direct any parameter change to phase C. Also used to update any quantity in the display identified as C=.
↑/REG	Used to increment the value in any output parameter screen or calibration screen. Also used to load the program register into any register identified by the preceding numeric value.
↓/REG	Used to decrement the value in any output parameter screen or calibration screen. Also used to recall the program register identified by the preceding numeric value.

TABLE 3-3

KEYPAD KEY DESCRIPTION

KEY	DESCRIPTION
CLR/SRQ	Used to clear the numerical inputs for the display screen.
MON	Used to display programmed output parameter values. Used repeatedly, it will cause the display screens of increasing numeric numbers to be displayed.
PRG	Used to program setup values in the Program Register. Used repeatedly, it will cause the display screens of decreasing numeric numbers to be displayed.
ENT	Used to transfer the contents of the program register to the actual output parameters.

TABLE 3-3 (continued)

KEYPAD KEY DESCRIPTION

3.5.2 DISPLAY SCREENS

A display of data on the front panel LCD display is called a screen. There are five types of screens: menu, output parameter, measurement, calibration and configuration screens.

Menu screens display the screen abbreviation with its equivalent number. The numeric value for each item in a menu screen is the code that may be used to select the screen. Tables 3-4 through 3-7 show the numeric values for all screens. Without the aid of the tables the MNU key may be used. The menu screens will display only the programmable features that are enabled and their associated screen number.

Table 3-4 shows all of the available Output Parameter screens. While viewing any of the screens, the associated output parameter may be changed from the keyboard.

Table 3-5 shows all of the Measurement screens. When accessing some Measurement screens up to three seconds may be required to display the screen.

Table 3-6 shows all of the screens for calibrating the output and measurement functions. A special code is required to access these screens. Refer to Section 4, Calibration.

Table 3-7 shows all of the Configuration screens. The only value that is user programmable is the IEEE-488 (GPIB) Listen Address.

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
The following are for changing the output:				
*2	CLK		INT, EXT	Selects the external clock mode of operation.
4	CUR		0.02 to Max Current (200 Standard)	Sets the output current.
5	VLT		0 to Max Voltage (270 Standard, 312 for HV Option)	Sets the output voltage.
6	FRQ		47 to 66	Sets the output frequency.
7	PHZ	A=VLT C=CUR	0-±999.9	Sets the output phase angle.
8	CRL		0 to Max Current (5.56 Standard 4.8 for HV Option)	Sets the current limit for the voltage outputs

*Optional screen. CLK is standard for the Phase B and C Power source

TABLE 3-4
OUTPUT PARAMETER SCREEN

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
The following are for measured values.				
11	ELT	H, M, S	Hrs,Min,Sec	Reports the total accumulated run time up to 9,999 hours.
21	VLT	MSR	0-312	Measures the TRMS output voltage.
22	CUR	MSR	0 to 2.000 2.01 to 20.00 20.1 to 200.0	Measures the TRMS output current in Amps. Range depends on the programmed value of current.
23	PWR	MSR	0 to 0.624 0 to 6.24 0 to 62.4	Measures the simulated true power output. The range depends on the programmed value of current.
26	FQM	MSR	47.00 to 66.00	Measures the output frequency in hertz.
27	PZM	MSR	0-359.9	Measures the phase angle

of the output current relative to the output voltage.

TABLE 3-5

MEASUREMENT SCREENS

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
12	CAL OUT	A=VLT C=CUR	0-255	Calibrated the programmed output voltage and current.
13	CAL VLT		Actual output voltage	Calibrates the measured voltage to be the same as argument
14	CAL CUR		Actual output current (amps)	Calibrates the measured current to be same as argument.
15	CAL PWR		Actual simulated output power	Calibrates the measured simulated power to be same as argument. The argument is in KW and should be = (VLT)*(CUR)* COS Ø. VLT and CUR are the actual output voltage and current. Ø is the phase angle between the voltage and current.
20	POF	A=VLT C=CUR	0-±359.9	Calibrates the programmed output phase angle.

TABLE 3-6

CALIBRATION SCREEN

NO.	SCREEN NAME	EXTENSIONS	ARGUMENT	ACTION TAKEN
16	CFG	A=LSN	0-30	Sets the IEEE-488 (GPIB) Listen Address.
		*B=CFB	28=PHASE A	Defines the features en
				29=PHASE B & C abled for Power Source compatibility.
		*C=PHZ	0=PHASE A 240=PHASE B 120=PHASE C	Defines the default phase angle for the Phase B and C Power Source.
17	LMT	*A=VLT	Maximum Voltage (270 Standard) (312 HV Option)	Defines the upper limit of the programmed output voltage.
		C=CUR	Maximum Current (200 Standard)	Defines the upper limit of the programmed output current.
18	FLM	A=FRQ	60	Defines the default frequency.
		*B=LLM	47	Defines the low frequency limit.
		*C=HLM	66	Defines the high frequency limit.
19	CLM	*A=CRL	Max Current (5.56 Standard) (4.8 HV Option)	Defines the maximum current limit value.

		*B=PRS	0	Not used.
		*C=CRS	0	Not used.
29	INI	A=VLT	0-5	Defines default voltage.
		C=CRL	0 - Max Current (5.56 Standard) (4.8 HV Option)	Defines the default Current Limit.

*NOT USER PROGRAMMABLE.

TABLE 3-7

CONFIGURATION SCREENS

3.5.3 TO PROGRAM OUTPUT VOLTAGE AMPLITUDE (VLT=5)

NOTE

The external sense lines must be connected to J6 on the rear panel of the AC Power Test System. If they are not properly connected an VLT FAULT message will result. Refer to Figure 2-3. For Phase B and C Power Sources the error message will also be displayed if the CLOCK and LOCK coaxial cables are not connected.

The output voltage is programmed independently for each phase of a 3-phase system. The examples shown below must be programmed on each of the controllers for the Phase B and C power sources.

Select the Voltage (VLT) screen by entering keystrokes:

5 ENT

The display now shows the VLT parameter screen:

VLT MON = 5.0

Program the output to 115.5 volts with the keystrokes:

115.5 PRG ENT

Slowly increase the output voltage:

↑ (Hold until desired value is obtained.)

3.5.4 TO PROGRAM FREQUENCY (FRQ=6)

To program the frequency of the AC Power Test System, enter the following key sequence into the controller for the Phase A Power Source:

Select the Frequency (FRQ) screen by entering the keystrokes:

6 ENT

Program the frequency to 60.23 hertz with the key sequence:

60.23 PRG ENT

To incrementally increase the output frequency to a desired value:

↑ (Hold until desired frequency is reached.)

NOTE

The frequency of either the Phase B or Phase C power source can be programmed independently from the Master Phase A power source by first programming the External Clock (CLK) mode before selecting the Frequency screen.

3.5.5 TO PROGRAM OUTPUT PHASE ANGLE (PHZ=7)

The following examples allow the voltage output from the Phase B and C power sources to be set relative to the Phase A power source.

Program the Phase C voltage output to .5 degree relative to Phase A by programming the Phase C controller with the following key sequences.

Select the Phase (PHZ) screen by entering:

7 ENT

Program the value by entering:

0.5 A PRG ENT

The up (↑) and down (↓) keys may be used to increment or decrement the output phase.

3.5.6 TO PROGRAM CURRENT LIMIT (CRL=8)

The Current Limit restricts the current from the voltage output.

1. Select the Current Limit screen by entering:

   8 ENT

2. Program the Current Limit to 5 amps:

5 PRG ENT

3.5.7 TO PROGRAM OUTPUT CURRENT (CUR=04)

NOTE

A load or short must be placed across the respective current output terminals when an output current is programmed. If the current output terminals do not have the correct output termination a 'CUR FAULT' error message will be generated. See the following for the maximum load resistance value.

PROGRAMMED CURRENT	OUTPUT TERMINALS	MAXIMUM COMPLIANCE VOLTAGE	MAXIMUM LOAD IMPEDANCE
2.00 Amps	20 Amp	200 volts	100 ohms
20.00 Amps	20 Amp	25 volts	1.25 ohms
200.0 Amps	200 Amp	7.5 volts	0.035 ohms

MAXIMUM CURRENT OUTPUT
LOAD IMPEDANCE

The output current is programmed independently for each phase of a 3-phase system.

The following key entry sequence will program 150 amps on the 200 amp output bus bars:

4 ENT To select the CUR screen

1 5 0 PRG ENT To program 150 amps.

While viewing the CUR screen any output current from 0.02 amp to 200.0 amps can be programmed. For values from 0.02 to 20.00 amps the output appears on the TB1 block.

To program .5 amps enter the following key sequence:

0.5 PRG ENT

3.5.8 TO PROGRAM THE CLOCK MODE (CLK=02)
(Phase B and C Power Sources only)

The Clock and Lock coaxial cables are used to drive the frequency and phase angle for the Phase B and Phase C power sources. At power-up the Phase B power source defaults to the External Clock mode with the phase angle of the voltage set to 240 degrees

relative to the voltage of the Phase A power source. The phase C power source also defaults to the External Clock Mode with the phase angle of the voltage output set to 120 degrees.

The frequency of the Phase B and C power sources is controlled by the Phase A controller. the Phase B and Phase C power source can be operated independently from the phase A power source by programming the B or C controller to the Internal Clock mode. In this mode the controller can program the output frequency of its own output.

To program the Internal Clock mode enter the following key sequence:

2 ENT To select the Clock (CLK) screen

INT PRG ENT To program the Internal Clock mode

The frequency of the power source can be programmed by entering the following key sequences:

6 ENT To select the Frequency (FRQ) screen

50 PRG ENT To program 50 Hz

3.5.9TO LOAD REGISTERS

The AC Power Test System has 16 registers that can be used to store setups. All of the data stored in the registers will be retained during power-down. The REC and REG keys are used for register operations. Any of the previous examples may be stored in a register by adding the extra step of entering the register number followed by depressing the REG key. This extra step must be entered before the last ENT keystroke.

The following example will load the data to program 135 volts, 200 amps and 60 hertz into register 0.

1. Select the FRQ screen and program 60 hertz:

   6 ENT 60 PRG

2. Select the VLT screen and program 135 volts:

   5 ENT 135 PRG

3. Select the CUR screen and program 200 amps:

   4 ENT 200 PRG

4. Store the program in register 0:

   0 REG ENT

To recall and perform the register operation, simply enter the register number followed by depressing the REC and ENT keys.

3.5.10 ERROR MESSAGES

Table 3-8 shows all of the possible error messages displayed on the front panel display. The cause of the error message is also shown.

3.5.11 TO PROGRAM FREQUENCY, VOLTAGE, AND CURRENT LIMIT DEFAULT VALUES

The default values are the values that appear at power-up and after the GPIB Device Clear command.

To set any of the default values perform the following steps:

1. Depress the MNU key several times until the first menu screen is displayed as illustrated below:

   *CLK = 02   CUR = 04

2. Enter the key sequence: 9 5 9 ENT

NOTE (*) This item is displayed for the Phase B and C power sources only.

ERROR MESSAGE	CAUSE
CUR FAULT	Excessive output impedance across current output terminals.
VLT FAULT	Incorrect sense line connection or overload on voltage output.
TEMP FAULT	Amplifier overtemperature
CPU MEMORY FAULT	CPU failed self-test
DMA OVERFLOW	Remote message greater than 256 bytes.
BUS LOCAL ERROR	Remote message sent while AC Power Test System is in local.

SYNTAX ERROR	Incorrect syntax received from IEEE-488 External Interface
VLT RANGE ERROR	Attempt to program VLT value greater than voltage limit.
FRQ RANGE ERROR	Attempt to program FRQ less than 47 or greater than 66 Hz.
PHZ RANGE ERROR	Attempt to program PHZ greater than ±999.9
CRL RANGE ERROR	Attempt to program CRL greater than the maximum current allowed for the voltage output (5.56 is standard).
CUR RANGE ERROR	Attempt to program CUR greater than the maximum current (200 amps is standard).
DIV ERROR	Consult factory.
OVERFLOW ERROR	Consult factory.

FRONT PANEL DISPLAY ERROR MESSAGES

TABLE 3-8

3. Depress the MNU key several times until the configuration menu screen is displayed as illustrated below:

CFG = 16	LMT = 17
FLM = 18	CLM = 19

To program the default frequency, enter the key sequence:

1 8 ENT A

next enter the default frequency followed by depressing the PRG and ENT key.

To program the default voltage, perform steps 1 through 3. Next enter the key sequence:

2 9 ENT A

At this point the default voltage from 0 to 5 may be entered. If a value of less than 5 volts is entered, the output may fault when a voltage is programmed to a value that is less than 50% of full scale.

To make 5 volts the default voltage, continue the key sequence with:

5 PRG ENT

To program the default current limit, perform steps 1 through 3. Next enter the key sequence:

2 9 ENT C

At this point, any value may be entered up to the maximum current available on the voltage output. This value is 5.56 for the standard 270 volt range.

To make 5 amps the default value, continue the key sequence with:

5 PRG ENT

3.6 TO MEASURE THE OUTPUT

Five measurement screens display the output voltage, current, simulate true power, phase and frequency.

While viewing any measurement screen, except ELT, any other measurement screen may be displayed by repeatedly depressing either the MON or PRG key. The screen may also be displayed by entering its equivalent screen number followed by depressing the ENT key. Refer to Table 3-5 for all measurement screen numbers.

3.6.1 TO MEASURE THE OUTPUT VOLTAGE (VLT=21)

The voltage screen displays the actual TRMS output voltage with 0.1 volt resolution. This voltage is the voltage at the External Sense connector of the AC Power Test System. To access the voltage screen, depress the keys:

2 1 ENT

3.6.2 TO MEASURE THE OUTPUT CURRENT (CUR=22)

The current screen displays the actual TRMS load current. The resolution is a function of the programmed output current. The resolution is 0.001 amp for program values from 0.000 to 2.000 amps. The resolution is 0.01 for program values from 2.01 to 20.00. The resolution is 0.1 amp for program values greater than 20.00 amps. To access the current measurement screen depress the keys:

2 2 ENT

3.6.3 TO MEASURE THE OUTPUT POWER (PWR=23)

The power screen displays the simulated output power. The simulated output power (P) is derived from the following relationship: P = V*I COS Ø.

The resolution of the measured output power is a function of the programmed output current. The resolution is 0.0002 KW for programmed current values from 0.000 to 2.000 amps. The resolution is 0.002 KW for current values from 2.01 to 20.00 amps. The resolution is 0.02 KW for currents greater than 20.00 amps.

To access the power measurement screen, depress the keys:

2 3 ENT

3.6.4 TO MEASURE THE OUTPUT FREQUENCY (FQM=26)

This screen is accessed by its screen number, 26. It displays the measured output frequency with a resolution of 0.01 Hz.

3.6.5 TO MEASURE THE OUTPUT PHASE ANGLE (PZM=27)

This screen is accessed by its screen number, 27. It displays the

phase angle between the current output and the voltage outputs. The current leads the voltage for + values. To access the screen, depress the following keys:

2 7 ENT

3.6.6 ELAPSED TIME (ELT =11)

This screen displays the total run time accumulated on the AC Power Test System up to 99,999 hours.

H = HoursM = Minutes S = Seconds

3.7 REMOTE PROGRAMMING WITH ABBREVIATED PLAIN ENGLISH (APE)

Remote programming through the IEEE-488 Interface (GPIB) consists of sending the unit address and the proper ASCII alphanumeric characters to identify the parameter and the numerical value or other argument. The description of the abbreviations for GPIB messages used in this section are listed in Table 3-9. These abbreviations must not be confused with the device dependent abbreviations used to describe the AC Power Test System operating parameters (ex. FRQ=Frequency, etc.).

3.7.1 UNIT ADDRESS

This is the A value (LSN) set in the CFG screen. The Unit Address 0 through 30 corresponds to the HEX value 20 through 3E. Refer to Table 3-10 for the equivalent HEX, Binary, ASCII and Decimal equivalents. The Unit Address is set at the factory to 1 but may be changed by selecting the CFG Configuration screen and setting a new value.

To select the CFG screen repeatedly depress the MNU key until menu screen #1 is displayed as illustrated below:

```
*CLK = 02      CUR = 04
```

Enter the key sequence: 959 ENT

Repeatedly depress the MNU key until the menu screen #5 is displayed as illustrated below:

```
CFG = 16       LMT = 17
FLM = 18       CLM = 19
```

Enter the key sequence: 16 ENT

The CFG screen will now be displayed. Depress the A key to display the present Unit Address. It may be changed to any value from 0 to 30 and will be stored in non-volatile memory. The new unit address will not be updated until power is shut off and reapplied to the power system.

The following key sequence will change the unit address to 16:

```
16 PRG ENT
```

NOTE (*): This parameter will be shown for only the Phase B and C power sources.

TABLE 3-9
COMMONLY USED GPIB ABBREVIATIONS

ABBREVIATION	DEFINITION
ATN	Attention. A logic line on the GPIB asserted only by the controller to indicate the data on the bus represents a bus message.
CR	An ASCII carriage return.
DCL	Device Clear. A universal bus message to initialize all instruments to their power-on states..
END	End. A message conveyed when a talker uses the EOI line with the last data byte of a data string.
EOI	End or Identify. A logic line on the GPIB asserted by a talker to indicate the last byte of a data string.
EOS	End of String. A delimiter message that consists of a data byte(s) to indicate the end of a data string.
GET	Group Execute Trigger. A GPIB message to trigger an addressed instrument.
GTL	Go To Local. A GPIB message to put an addressed instrument in the local control mode.
IFC	Interface Clear. A logic line on the GPIB asserted by the controller to clear all interfaces (ex., default to unlisten and untalk).
LF	An ASCII line feed.
LLO	Local Lockout. A GPIB message, when asserted, will inhibit the instrument from going to local if the CLR/LOC key is pressed.
REN	Remote Enable. A logic line on the GPIB asserted by the controller. REN enables an instrument to go to local when addressed.

SDC	Selected Device Clear. A GPIB message to initialize an addressed instrument to it Power-on state.

TABLE 3-10

UNIT ADDRESS GROUP

LISTEN ADDRESS	HEX	BINARY	A5	A4	A3	A2	A1	DECIMAL	ASCII
0	20	001	0	0	0	0	0	32	SP
1	21	001	0	0	0	0	1	33	!
2	22	001	0	0	0	1	0	34	"
3	23	001	0	0	0	1	1	35	#
4	24	001	0	0	1	0	0	36	$
5	25	001	0	0	1	0	1	37	%
6	26	001	0	0	1	1	0	38	&
7	27	001	0	0	1	1	1	39	'
8	28	001	0	1	0	0	0	40	(
9	29	001	0	1	0	0	1	41	)
10	2A	001	0	1	0	1	0	42	*
11	2B	001	0	1	0	1	1	43	+
12	2C	001	0	1	1	0	0	44	'
13	2D	001	0	1	1	0	1	45	-
14	2E	001	0	1	1	1	0	46	.
15	2F	001	0	1	1	1	1	47	/
16	30	001	1	0	0	0	0	48	0
17	31	001	1	0	0	0	1	49	1
18	32	001	1	0	0	1	0	50	2
19	33	001	1	0	0	1	1	51	3
20	34	001	1	0	1	0	0	52	4
21	35	001	1	0	1	0	1	53	5
22	36	001	1	0	1	1	0	54	6
23	37	001	1	0	1	1	1	55	7
24	38	001	1	1	0	0	0	56	8
25	39	001	1	1	0	0	1	57	9
26	3A	001	1	1	0	1	0	58	:
27	3B	001	1	1	0	1	1	59	;
28	3C	001	1	1	1	0	0	60	<
29	3D	001	1	1	1	0	1	61	=
30	3E	001	1	1	1	1	0	62	>
UNL	3F	001	1	1	1	1	1	63	?

3.7.2 MESSAGE FORMAT

The message sent to the AC Power Test System must have the following format for each parameter:

HHHDXXX---------------E±NND

where

H = Three letter mnemonic for each message header.

D = Optional header extension (VLT or CUR) to specify output (ref. Table 3-4 through 3-7)

X = Alpha, numeric or # for message header argument.
E = Optional ASCII E for exponent identification
± = Exponent sign
N = Exponent value 0 to ±63
D = Message string delimiter, (CR) (LF) or (LF)

More than one message header with its corresponding argument may be sent in one setup string with a common delimiter.

3.7.3NUMERIC DATA FIELD

Parameter values may be sent as an unsigned value with a decimal point or a decimal point with an exponent. The phase value may be sent as a signed value.

The Decimal Point for numeric data values may be either sent or inferred. The two following ASCII strings will represent 115 volts.

VLT115
VLT115.0

There may be any number of digits following the decimal point, not to exceed the 256 byte DAM buffer, but only the Least Significant Digit (LSD) of resolution will be recognized. The LSD for amplitude is 0.1 volts. The LSD for frequency is 0.01 Hz.

Any parameter's numeric value may be of a mixed form with a decimal point and exponent. The exponent may be a numeric, with or without leading zeros, up to a value of ±63. The following ASCII strings will represent 15 volts:

```
VLT1.15E2
VLT1.15E+2
VLT1.15E+02
VLT1150E-1
```

A positive exponent value is represented by either an ASCII "+" or an unsigned value.

3.7.4 PROGRAM HEADERS

A Program Header is a mnemonic of a series of three ASCII characters used to select a function or identify the data it precedes. The header is an abbreviation of the program function it identifies. The PHZ header must be followed by a header extension to separately program each output (VLT or CUR) to different values. See Table 3-11 for the definition of the Program Headers and their related arguments.

Any header that is sent without an argument will cause the front display to show the corresponding screen. Refer to Figure 3-4 for a summary of all possible command sequences.

TO LOAD A REGISTER AND/OR PROGRAM OUTPUT PARAMETERS

```
-->VLT--(n)->PHZ--VLT-(n)->CLK-INT->REG-(n)---------->
 | CUR     |      CUR     |     EXT|        |
 | FRQ     |              |        |        |
 |         |              |        |        |
 |--------->------------->-------->-------->--------->
```

TO REQUEST TALKING OF CALIBRATION COEFFICIENTS

```
   -->TLK-----CAL-|VLT    |--->
                  |CUR    |
                  |MSR VLT|
                  |MSR CUR|
                  |MSR PWR|
```

FIGURE 3-4

REMOTE COMMAND SEQUENCES

TO SPECIFY THE SERVICE REQUEST INTERRUPT:

```
-->SRQ--(n)---->
```

TO CALIBRATE THE OUTPUT VOLTAGE OR CURRENT

```
-->CAL---VLT--(n)---->*
         CUR
```

TO CALIBRATE THE OUTPUT PHASE ANGLE

```
--->POF---A--(n)------>*
          C
```

TO REQUEST TALKING A PROGRAMMED PARAMETER OR MEASURED VALUE:

```
-->TLK--->|VLT    |--->*
          |CUR    |
          |FRQ    |
          |CRL VLT|
          |CLK    |
          |PHZ VLT|
          |PHZ CUR|
          |PZM C  |
```

TO RECALL A REGISTER

```
--->rec--(n)-------->*
```

NOTE(*): Represents either an IEEE-488 END or EOS message. The EOS message may be either an ASCII Carriage Return (CR), Line Feed (LF) or only LF.

FIGURE 3-4 (continued)

REMOTE COMMAND SEQUENCES
TABLE 3-11
PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
VLT		0.0 to Max Voltage (270 Standard) (312 HV Option)	Output voltage in volts
CAL	VLT	0 to 255	Calibrate the output voltage
CAL	CUR	0 to 255	Calibrate the output current
CAL MSR	VLT	Actual voltage	Calibrated measured voltage at external sense point.
CAL MSR	CUR	Actual current	Calibrate measured current.
CAL MSR	PWR	Actual power	Calibrate measured simulated power.
* CLK		INT, EXT	Clock source
CRL		0 to max. Current (5.56 Standard) (4.8 HV Option)	Current limit in amps
CUR		0.02 to Max Current (200 Standard)	Output current in amps.
FRQ		47.00 to 66.00	Frequency in hertz.
PHZ	VLT	0 to 999.0	Phase angle in degrees.
PHZ	CUR	0 to 999.0	Current phase angle in degrees
PRG		0 through 15	Load register with preceding data.
REC		0 through 15	Recall register or specify link register if it is preceded by program argument followed by PRG and

			register number.
REG		0 through 15	Register load

NOTE (*): CLK is available for only the Phase B and C power source

TABLE 3-11 (CONT.)

PROGRAM HEADERS

HEADER	EXTENSION	ARGUMENT	DEFINITION
SRQ		0, 1 or 2	Service Request disable, enable or at completion of program and measurements.
TLK		Any header	Set up to talk argument value or measured value when addressed to talk.
TRG			Execute (Trigger) set-up parameters on GPIB "GET" message.
MSR	VLT		Used with TLK to request measurement of the output voltage.
ELT			Used with TLK to request total accumulated run-time.
MSR	CUR		Used with TLK to request measurement of the output load current.
MSR	PWR		Used with TLK to request measurement of the simulated true power (V*A COSØ)
PZM	C		Used with TLK to request measurement of the output current relative to voltage phase angle.
FQM			Used with TLK to request

measurement of the output frequency.

3.7.5 TO PROGRAM OUTPUT VOLTAGE (VLT)

The VLT header is used to identify the voltage command. The argument is a numeric data field from 0.0 to the maximum voltage (270 standard). An attempt to program a value higher than this value will generate an error and a SRQ on the GPIB.

The following ASCII strings will program the voltage given in the left column:

0.0 volts	VLT0				
10.5 volts	VLT10.5	or	VLT1.05E1	or	VLT105E-1
100 volts	VLT100	or	VLT100.0	or	VLT1E2

3.7.6 TO PROGRAM FREQUENCY (FRQ)

The FRQ header is used to identify the following numeric data as frequency.

The following string will program the frequency to 60.56 Hz.

```
FRQ 60.56
```

3.7.7 TO PROGRAM PHASE ANGLE (PHZ)

The PHZ header with the VLT or CUR extension is used to identify the following numeric data as phase. The PHZ header with VLT extension will program the phase angle of the voltage output relative to the Phase A power source. The PHZ header with the CUR extension will program the phase angle of the current output relative to the voltage output of the same power source.

The following example will program the current output to 90 degrees relative to the voltage output from the same power source:

```
PHZ CUR 90
```

3.7.8 TO PROGRAM CURRENT LIMIT (CRL VLT)

The CRL header with the VLT extension is used to identify the Current Limit Command. The argument is a numeric data field from 0.0 to the maximum rated current of the power system. The maximum current is 5.56 amps for the standard 270 volt range. The maximum current for the HV Optional Voltage range of 312 volts is 4.8

amps.

The following string will program a current limit of 5.0 amps:

CRL VLT 5

3.7.9 TO PROGRAM CALIBRATION (CAL)

The CAL header when used with the VLT or CUR extension is for calibration of the output voltage or current respectively. The argument is a relative coefficient from 0 to 255. A value of 0 will adjust the output to a minimum. For remote calibration a IEEE-488 controller/computer can be used to monitor the output from an external precision voltmeter or ammeter. The IEEE-488 Controller/computer can then adjust the calibration coefficient of the output voltage or current to calibrate the output to the programmed value.

To program the CAL coefficient of the current output to 127 send the following string:

CAL CUR 127

The CAL header with the extensions of MSR VLT, MSR CUR and MSR PWR are used to calibrate the measurement system for voltage, current and power respectively. The argument is a numeric value that represents the expected measured value. The argument should be equal to the value derived from an external precision TRMS voltmeter or ammeter.

The value for power (P) must be derived from the following formula:

P = V*I COS Ø

where: V is the actual output voltage.

I is the actual output current.

Ø is the phase relationship between the current and voltage for the individual power source..

If the output current is calibrated first, (I) can be the programmed value. If the phase angle of the current is programmed to 0.0, Ø= 0 degrees. (V) must be derived from an external TRMS voltmeter for the greatest accuracy at full simulated power (270 volts).

NOTE

There are three (3) calibration coefficients for current and three (3) for power. Current measurement calibration must be performed at 2, 20 and 200 amps. Power measurement calibration must also be performed at 2, 20 and 200 amps with the output voltage programmed to 270.0 volts.

3.7.10 TO PROGRAM A REGISTER (REG)

The REG header is used to load a register with the preceding data. A register is identified by a numeric value from 0 to 15. The PRG header is identical to the REG header and is included to standardize other AC power controllers.

The following example will load the output parameters of 270 volts, 19 amps and 60 Hz into Register 0"

```
FRQ 60 VLT 270 CUR 19 REG 0
```

3.7.11 TO RECALL A REGISTER (REC)

The REC header is used to recall previously loaded data from a register identified by the following register number (0 to 15).

The following example recalls and outputs the parameters stored in register 0 by an example in paragraph 3.7.10.

```
REC0
```

The following example recalls the parameters in register 0 and outputs the parameters after the IEEE-488 "GET" message.

```
REC0 TRG
```

3.7.12 TO PROGRAM EXTERNAL CLOCK (CLK)
(Phase B and C Power Sources only)

The CLK header has an argument of either EXT or INT. The CLK header with the EXT argument will make a Power Source a slave. The slave will operate at the same frequency as the master. The voltage output of the slave will be related to the voltage output of the master by the PHZ value of the slave.

The following ASCII string will program the Phase A or B Power Source to the Internal Clock mode:

CLK INT

The power source can now be frequency programmed independent from the Phase A power source.

NOTE

If there is no signal at the CLOCK input at the rear panel of the associated power system in the EXT Clock mode, the output will go to zero volts.

The ASCII string CLK EXT will return the slave AC Power Source to the programmed frequency of the Phase A power source.

3.7.13 TO TRIGGER AN OPERATION (TRG)

The TRG header has no argument. When the TRG mnemonic is included in a setup string, it will delay execution of the string until the GPIB Device Trigger message is sent by the bus controller. The TRG header may also be used to trigger register operations by including the TRG header with the string used to recall a register. The following example will delay execution of the program in register 1 until an IEEE-488 Device Trigger is received:

REC1 TRG

The Trigger mode may also be enabled in the local mode by programming setup parameters without depressing the ENT key. The setup values will then be programmed in the remote mode when the Device Trigger is received.

3.7.14 TO PROGRAM THE DEFAULT FREQUENCY (FLM A)

The default frequency is the output frequency after power-up or after an IEEE-488 Device Clear.

The following example will program the default frequency to 50 Hz.

FLM A 50

3.2.15 TO PROGRAM THE DEFAULT OUTPUT VOLTAGE (INI A)

The default voltage is the output voltage after power-up, IEEE-488 Device Clear, voltage or current fault.

The following example will program the default voltage to 5 volts.

INI A 5

NOTE

> If the default voltage is programmed to a value less than 5 volts, the settling time will increase. In addition, there may be an amplitude fault when the voltage is programmed from the default voltage to a value less than 50% of full scale.

3.7.16 TO PROGRAM THE DEFAULT CURRENT LIMIT (INI C)

The default current limit is the value after power-up or IEEE-488 Device Clear.

The following example will program the default current limit to 1 amp.

INI C 1

3.7.17 TO TALK (TLK) MEASURED AND PROGRAMMED DATA

The TLK header will setup the AC Power Test System to talk data. The TLK header will setup the AC Power Test System to report a programmed output parameter if the program header is the argument for the TLK header.

To setup the AC Power Test System to report a measured value, attach a measurement header as the TLK MSR argument. The measurement headers are VLT, CUR and PWR.

The following string will setup the AC Power Source to measure the output current when it is talk addressed:

TLK MSR CUR

To setup the AC Power source to report the measurement of phase angle or frequency, use the TLK arguments of PHZ C and FQM respectively. The following string will setup the AC Power Source to measure the phase angle between the voltage and current output when it is talk addressed:

TLK PZM C

A GPIB Service Request (SRQ) will be generated at the completion of a measurement if the SRQ2 header is included with the TLK string. The following string will cause the Service Request to be

generated when the power system has finished the power factor measurement.

TLK PWF SRQ2

3.7.18 TO TALK THE MEASURED OUTPUT VOLTAGE (TLK MSR VLT)

MSR VLT may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Test System to measure the output voltage with 0.1 volt resolution.

When VLT is used as a header in a string with no argument, it will cause the front panel to display the measured output voltage.

3.7.19 TO TALK THE MEASURED OUTPUT CURRENT (TLK MSR CUR)

MSR CUR may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Test System to measure the output current in amps with 0.001 amp resolution up to 2.000 amps. The resolution is 0.01 amp up to 20 amps and 0.1 amp up to 200 amps.

When CUR is used as a header in a string with no argument, it will cause the front panel to display the output current.

TABLE 3-12
TLK ARGUMENTS

ARGUMENT	EXTENSION	DATA REPORTED	DEFINITION
LMT	A C	*270 (312 HV) *200	Maximum voltage Maximum current
VLT	None	0 to *270.0 (312 HV)	Programmed output voltage value in volts.
CFG	A B C	0 to 30 28 or 29 0, 120 or 240	IEEE-488 Listen Address Configuration Code Phase A, C or B Power Source
CLM	A B C	*5.56 (4.8 HV) 0 0	Defines the maximum current Not used Not used
CRL		0 to *5.56 (4.8 HV)	Programmed output current limit.
MSR CUR		0.000 to 200.0	Measurement of output current.

ELT	A B C	0000 to 9999 00 to 59 00 to 59	Total accumulated hours (H) Accumulated minutes (M) Accumulated seconds (S)
FLM	A B C	60 47 66	Default frequency Low frequency limit High frequency limit
FQM	None	47.00 to 66.00	Measured output frequency
FRQ	None	47.00 to 66.00	Programmed frequency
INI	A C	0000 to 005.0 O to *5.56 (4.8 HV)	Default voltage Default current limit
PHZ	VLT, CUR	0.0 to 359.9	Programmed output phase angle
MSR PWR		0 to 54.00 (62.4 HV) 0 to 5.400 (6.24 HV) 0 to 0.5400 (0.624 HV)	Power in kilowatts. MSR PWR = V*A COS Ø
PZM C		0 to 359.9	Measured phase angle of the current output relative to the voltage output.
REG	0 to 15	Contents of Reg	Talk contents of register
SRQ	None	0, 1 or 2	Programmed SRQ status
MSR VLT		0.0 to 270	Measured output voltage

(*) Standard values shown. Values will be different for other ranges, output power and options. The optional values are shown by ( ).

TABLE 3-13

EXAMPLE TALK RESPONSE (3-PHASE SYSTEM)

ASCII STRING SENT	RESPONSE AFTER ADDRESSED TO TALK		
TLK LMT	LMTA270.0		C200.0
TLK VLT	VLT005.0		
TLK CFG	CFGA0001	B0028	C0120
TLK CLM	CLMA05.56	B0000	C0000
TLK CRL VLT	CRLVLT05.56		
TLK CUR	CUR190.0		
TLK ELT	ELTH0147	M0051	S0033
TLK FLM	FLMA0060	B0047	C0066
TLK FQM	FQM59.97		
TLK FRQ	FRQ60.00		

TLK	CLK	CLK INT (*)	
TLK	PHZ	PHZV000.0	C120.0
TLK	MSR PWR	PWR53.94	
TLK	PZM	PZM000.0	
TLK	REG0	ACTUAL CONTENTS OF REGISTER 0	
TLK	MSR VLT	VLT270.0	
TLK	MSR CUR	CUR190.0	

NOTE (*): A Syntax Error message will be generated from the Phase A Power source.

3.7.20 TO TALK THE MEASURED SIMULATED OUTPUT POWER (TLK MSR PWR)

MSR PWR may be used as an argument to the header TLK. When used as an argument, it will set up the AC Power Test System to measure the output power in kilowatts. The resolution is a function of the programmed output current. The resolution is 0.0002, 0.002 or 0.02 for a current of 0.02 to 2, 2.01 to 20.00 or 20.1 to 200 amps, respectively.

When MSR PWR is used as a header in a string with no argument, it will cause the front panel to display the output power.

3.7.21 TO TALK THE MEASURED OUTPUT FREQUENCY (TLK FQM)

FQM may be used as an argument to the header TLK. There are no extensions for this argument. When FQM is used as an argument, it will set up the AC Power Test System to measure the output frequency in hertz.

When FQM is used as a header, it will cause the front panel to display the measured output frequency.

3.7.22 TO TALK THE MEASURED OUTPUT PHASE ANGLE (TLK PZM C)

PZM C may be used as an argument for the header TLK. When used as an argument, PZM C will set up the AC Power Test System to measure the phase angle of the output current relative to the output voltage.

When PZM C is used as a header, it will cause the front panel to display the phase measurement screen.

3.7.23 MESSAGE SEPARATORS

A complete message consists of a header and an argument. Since more than one message can be sent in a setup string, message separators included in the string between the message will make it more readable to the human operator. Three message separators are recognized: the comma (,), semicolon (;) and a space. Since these separators are ignored, they may be dispersed throughout a setup string.

The following are two examples of ASCII strings with separators:

```
PHZA90;FRQ60;VLT115

CRL VLT, 5; FRQ50; VLT, 120
```

3.7.24 SERVICE REQUEST

After power-up the GPIB Service Request (SRQ) will be generated after any error (example. syntax, output fault, etc.). This SRQ output can be inhibited by the SRQ header followed by the single digit "0". The SRQ can be reenabled by the SRQ header followed by 1. Sending SRQ2 causes an SRQ to be generated after the execution of a setup string or when data is available after request of measurements. The setup string can be of any type: ramp, calibration, etc.

The following example disables GPIB SRQ.

```
SRQ0
```

3.7.25 SERIAL POLL STATUS BYTE

Once the bus controller has detected the SRQ, it must determine the instrument needing service by the Serial Poll. During the polling routine the instrument needing service will return a Status Byte (STB) greater than decimal 63. The Status Byte values for various faults are given in Table 3-14.

3.7.26 END OF STRING

The End of String (EOS) delimiter recognized by the AC Power Test System is the ASCII Line Feed (LF). Carriage Return (CR) followed by Line Feed may also be used for EOS. The End or Identify (EOI) IEEE-488 message END will also be recognized. The END message is sent by setting the IEEE-488 End or Identify line true with the last data byte.

3.7.27 ERROR MESSAGES

Table 3-14 shows all of the possible error messages that can be generated by the AC Power Test System. These messages will also be displayed on the front panel of the AC Power Test System.

3.7.28 GROUP EXECUTE TRIGGER

The trigger mode is enabled when the mnemonic TRG is added to a setup string. The trigger command may be inserted anywhere in the string. When the mnemonic is detected, it will delay execution of the new setup values until the GPIB Device Trigger is sent by the bus controller.

A GPIB Device Trigger will also terminate a programmed ramp or other program.

The following setup string will recall the values from register 9 and delay execution until the GET message is received. (Note:

GET is the abbreviation for the GPIB Group Execute Trigger message and does not represent a series of ASCII characters. (See Table 3-9).

REC9TRG

3.7.29 SIMULTANEOUS VOLTAGE/CURRENT PROGRAMMING

Each of the three power sources that comprise the 3-phase AC Power Test System has an AC power controller. Each controller has its own IEEE-488 Listen Address. To change the output parameters simultaneously on each of the three phases, each power source must be set up with the desired parameters. The setup string must use the TRG appended to the string.

The following example assumes that each power source has its own Listen Address. The example will set up Phase A to 240 volts, 200 amps. Phase B will be set up to 242 volts, 190 amps and Phase C will be set up to 230 volts, 185 amps.

The following string is for the Phase A power source:

VLT 240 CUR 200 TRG

The following string is for the Phase B power source:

VLT 242 CUR 190 TRG

The following string is for the Phase C power source:

VLT 238 CUR 185 TRG

The outputs for the three power sources will change simultaneously when they receive an IEEE-488 Group Execute Trigger.

TABLE 3-14

STATUS BYTE VALUES

SRQ 1	SRQ 0	REPORTED MESSAGE	CAUSE
64	0	VLT FAULT	Overload or sense line fault
71	7	CUR FAULT	Current output excessive compliance voltage
72	8	TEMP A FAULT	A1 Voltage amplifier overtemperature
73	9	TEMP B FAULT	A2 Current amplifier overtemperature
75	11	TEMP C FAULT	A3 Current amplifier overtemperature
90	26	CUR RANGE ERROR	CUR value greater than highest range
91	27	VLT RANGE ERROR	VLT value greater than 270V or 312V
92	28	FRQ RANGE ERROR	FRQ value is less than 47 or greater than 66 Hz
93	29	PHZ RANGE ERROR	PHZ value greater than ±999.0
94	30	CRL RANGE ERROR	CRL value greater than maximum value
96	32	SYNTAX ERROR	Wrong string SYNTAX
97	33	BUS LOCAL ERROR	Remote message sent while in local mode
99	35	CPU MEMORY FAULT	CPU failed self-test
100	36	DMA OVERFLOW ERROR	Remote message greater than 256 bytes
63			The response after SRQ2 is included in a setup string and the execution of the string or measurement is completed.
	40	STA OK	No problems

caution page

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SECTION 4

CALIBRATION PROCEDURE

4.1 GENERAL

The calibration is divided into two categories; a periodic and a nonperiodic calibration. The periodic calibration should be performed at a 1 year interval. The nonperiodic calibration should only be performed if the periodic calibration cannot be performed or if an adjustable subassembly is replaced.

The following is a listing of paragraphs that may be performed to fix an indicated problem. Any AC Power Test System with a 1-phase output or that has more than one chassis will have paralleled amplifiers.

PARAGRAPH	TITLE
4.3.1	OUTPUT VOLTAGE CALIBRATION This is a periodic calibration of the output voltage.
4.3.2	VOLTAGE MEASUREMENT CALIBRATION This is a periodic calibration of the voltage measurement function.
4.3.3	CURRENT OUTPUT AND MEASUREMENT CALIBRATION This is a periodic calibration of the current output and measurement function.
4.3.4	POWER MEASUREMENT CALIBRATION This is a calibration of the power measurement function.
4.4	REMOTE MEASUREMENT CALIBRATION
4.5	REMOTE OUTPUT CALIBRATION
4.6.1	OUTPUT FREQUENCY CALIBRATION This is a nonperiodic calibration of the output frequency.
4.6.2	VOLTAGE GAIN ADJUSTMENT This is a nonperiodic adjustment. It may be required if a VLT FAULT error message is generated without a

load on the voltage output.

4.6.3 CURRENT GAIN ADJUSTMENT

These are nonperiodic adjustments. The adjustments are required if a CUR FAULT error message is displayed.

4.6.4 PHASE ANGLE CALIBRATION

This is a nonperiodic adjustment. The calibration is required if there is a phase error between the output current and voltage or between voltage outputs of a 3-phase system.

4.6.5 CURRENT LIMIT CALIBRATION

This is a nonperiodic calibration. The calibration is required if the available output current from the 270 volt output terminals is not equal to the programmed current limit value. The available output current may exceed the programmed value by 10%.

4.2 TEST EQUIPMENT

The following equipment or their equivalents are required to completely test the AC Power Test System.

1. Current Shunts:
   - 0.1 ohm/2 amp: Isotek Model RUG-Z-R100-.1
Leeds & Northrup CAT No. 4221
   - 0.01 ohm/20 amp: Isotek Model RUG-Z-R010-.1
Leeds & Northrup CAT. No. 4222
   - 0.001 ohm/200 amp: Isotek Model RUG-Z-R001-.1
2. Digital Voltmeter: Fluke Model 8840A (modified per CIC005) or equivalent. DVM must be calibrated at 60 Hz instead of standard 1 KHz.
3. Current Transformers: Pearson Model 110 and 3468
4. Resistive Loads: Voltage output - 48.6 ohms, 1500 watt
200 amp load - James Biddle JAGAV1 carbon pile
20 amp load - 1.25 ohm/500 watt
5. Distortion Analyzer: Hewlett Packard 339A

6. Phase Angle Meter: Krohn-Hite 6500A

4.3 PERIODIC CALIBRATION

The following periodic calibration adjustments should be performed on a 1 year interval.

4.3.1VOLTAGE OUTPUT CALIBRATION

Connect the Remote Sense lines to the voltage output terminals on TB1. Connect the AC DVM to the sense lines without an output load. Allow at least a 15 minute warmup period before calibration. Refer to Figure 4-1 for equipment hook-up.

1. Program the output to 135.0V rms and 60 Hz.

   NOTE:If a Phase B or C source is not calibrated as a system, the CLK must first be programmed to INT before proceeding.

2. Press the MNU key several times until the first Menu screen is displayed.

   ```
   *CLK=02   CUR=04
   ```

   FIRST MENU SCREEN

   NOTE(*): Shown only with Phase B and C power source.

3. Enter the password 9 5 9 followed by depressing the ENT key. Press the MNU key several times until the menu screen 16 is displayed as shown below.

   ```
   CFG=16    LMT=17
   FLM=18    CLM=19
   ```

4. Enter the key sequence 1 2 following by depressing the ENT key to display the Output Calibration screen. Press the A key for voltage calibration.

5. Press the UP (↑) or Down (↓) key to select a new output calibration value. Hold the key until the output voltage is the same as the programmed value, 135.0 ±0.05V rms. Press the ENT key to permanently store the value.

6. Repeat steps 1 through 5 for the other output phases to be calibrated. Connect the external AC DVM to the sense lines of the output to be calibrated.

4.3.2 VOLTAGE MEASUREMENT CALIBRATION

The voltage measurement is calibrated at 135 volts and 60 hz. Program the output to these parameters before starting the calibration.

Before calibration of voltage measurement first perform the output voltage calibration. While viewing the CAL OUT screen in paragraph 4.3.1, press the MON key one time to display the CAL VLT screen. If this procedure does not display the CAL VLT screen, perform steps 2 and 3 of paragraph 4.3.1. Then enter the key sequence 1 3 followed by depressing the ENT key.

1. Enter the key sequence 1 3 5 PRG ENT to perform the calibration at 135 volts.

2. Repeat the procedure for the other phases.

4.3.3CURRENT OUTPUT AND MEASUREMENT CALIBRATION

The programmed output current can be calibrated at 5 different program values on the 200 and 20 amp ranges. The 2 amp range will accept up to 6 calibration values. It is not necessary to calibrate all 16 values. In many cases it may be sufficient to only calibrate at or near the maximum value of the range. At the factory the current is calibrated at 10 program values.

If all of the cardinal calibration points for a current range are in error, they may be cleared from memory by performing the following steps. Refer to Figure 4-1 for the equipment hook-up for calibration.

1. Select the output current screen with the key sequence:

   4 ENT.

2. Enter the value of current to be programmed for calibration. Start at the top of Table 4-1 for the first program value of current.

3. Select the Current Calibration screen with the following key sequence.

   - Press the MNU key until the first MNU screen is displayed. Refer to paragraph 4.3.1, step 2.

   - Enter the key sequence: 9 5 9 ENT.

- Press the MNU key several times until the menu with screen 16 is displayed.

- Select the CAL OUT screen with the key sequence:
  1 2 ENT.

4. Press the B key to display the cardinal current calibration point. Press the C key to display the active calibration value. The value may be any value from 0 to 255. At this point if the CLR key is pressed three times, all of the calibration values for the active current range will be cleared. This may be the appropriate action if calibrations values other than those listed in Table 4-1 are chosen.

Figure 4-1 Equipment Hookup for Voltage and Current Calibration

PROGRAM VALUE	CURRENT OUTPUT TERMINALS	CALIBRATE OUTPUT	CALIBRATE MEASUREMENT	TEST SETUP FIGURE 1 CURRENT SHUNT	ADJUST TO AC DVM VALUE/RANGE	MAX. ADJ ±ERROR
190.0	200	YES	YES	.001 ohm	190.00/200mV	0.200mV
120.0	200	YES	NO	.001 ohm	120.00/200mV	0.200mV
60.0	200	YES	NO	.001 ohm	60.00/200mV	0.200mV
47.5	200	YES	NO	.001 ohm	47.50/200mV	0.200mV
19.00	20	YES	YES	.010 ohm	190.00/200mV	0.200mV
15.00	20	YES	NO	.010 ohm	150.00/200mV	0.200mV
12.0	20	YES	NO	.010 ohm	120.00/200mV	0.200mV
6.00	20	YES	NO	.010 ohm	60.00/200mV	0.200mV
4.75	20	YES	NO	.010 ohm	47.50/200mV	0.200mV
1.900	20	YES	YES	.100 ohm	190.00/200mV	0.200mV
1.500	20	YES	NO	.100 ohm	150.0/200mV	0.200mV
1.200	20	YES	NO	.100 ohm	120.00/200mV	0.200mV
0.600	20	YES	NO	.100 ohm	60.00/200mV	0.200mV
0.475	20	YES	NO	.100 ohm	47.50/200mV	0.200mV

FIGURE 4-1

CURRENT OUTPUT AND MEASUREMENT

Additional calibration values may be added at any time if any are available for the programmed current range.

After pressing the B key, the calibration points for the active current range can be displayed by pressing the Up (↑) or Down (↓) key.

5. Press the C key to display the calibration coefficient. If the value is 0, enter a value of 127 to speed the calibration process with the key sequence: 1 2 7 PRG ENT.

6. Press the C key again to display the calibration coefficient. Press the Up (↑) or Down (↓) key to obtain the precise calibration value for the correct output current. Press the ENT key to store the value.

7. If Table 4-1 indicates that the current measurement must be calibrated for the programmed current value, select the CAL CUR screen with the key sequence: 1 4 ENT.

8. Program the current measurement value. For example, enter the key sequence 190 if the measurement value should display 190.0 amps.

9. Continue with the current calibration by selecting the current program screen. Enter the key sequence: 4 ENT.

10. Repeat steps 2 through 9 for the next program value in Table 4-1.

4.3.4 POWER MEASUREMENT CALIBRATION

1. Short the 200 amp and 20 amp outputs.

2. Program the outputs to 270 volts, 2 amps and 60 Hz. Program the phase angle of the current output to 0.0 degrees. Connect the external DVM to the voltage output and note the voltage to calculate the power calibration value in step 4.

3. Select the CAL PWR screen. Follow the procedure in paragraph 4.3.3, step 3, to select the screen. The CAL PWR screen number is 15 instead of 12.

4. Determine the calibration value by multiplying the actual output voltage and the 2 amp output current. The value must be in KW (example 0.54).

5. Program 20 amps. Select the CAL PWR screen and enter the

calibration value obtained by multiplying the actual output voltage and the 20 amp output.

6. Program 200 amps. Select the CAL PWR screen and enter the calibration value. Again the value is obtained by multiplying the actual voltage and the actual output current. The value must be in Kilowatts.

4.4 REMOTE MEASUREMENT CALIBRATION

The measurement function of the AC Power Test System may be remotely calibrated. The equipment hookup is the same as before except an IEEE-488 Controller must be used to program the AC Power Test System. The values for the VLT, CUR and PWR strings must be derived from the external AC Digital Voltmeters and Current Shunt.

To calibrate the measured voltage, first program the AC Power Test System to 135.0 volts and 60 Hz. Send the following calibration string:

CAL VLT (Desired voltage value)

To calibrate the measured current send the following string:

CAL CUR (Desired current value)

To calibrate the measured power value send the following string:

CAL PWR (Desired power value)

4.5 REMOTE OUTPUT CALIBRATION

The output voltage and current can be calibrated through the IEEE-488 interface. Refer to paragraph 4.3.1 and 4.3.3 for the hook-up of the test equipment and calibration points.

To calibrate the output voltage first program the output voltage to 270 volts by sending the following IEEE-488 string"

VLT 270

If the output voltage is less than the programmed value of 270 the calibration coefficient must be increased. To determine the voltage calibration coefficient send the following string:

TLK CAL VLT

When the power source is addressed to talk it will report:

CAL VLT nnnn

The calibration coefficient, nnnn, will be a number from 0000 to 0255. If the coefficient is reported as 127, send the following string to increase the output voltage by approximately 0.01%:

CAL VLT 128

Increment the calibration coefficient until the output voltage is within specification.

If the output voltage is greater than the programmed value, send a calibration coefficient that is less than the existing value.

The output current can be calibrated similar to the output voltage. First program the output current to be calibrated. Then determine the calibration coefficient by sending the following string:

TLK CAL CUR

The calibration coefficient that is reported after the AC power source is addressed to talk can be incremented or decremented by the nnn values in the following string:

CAL CUR nnn

Refer to the examples for remote voltage calibration for additional information.

4.6 NONPERIODIC CALIBRATION

If adjustments are required for these nonperiodic calibrations, the top cover of the AC Power Source will have to be removed. A nonperiodic calibration will only be required if a related assembly is repaired or if the performance is out of specification.

4.6.1 OUTPUT FREQUENCY CALIBRATION

Connect the Frequency Counter to the voltage output. Program the output to 135.0 volts and 60.0 Hz. Engage the low-pass filter on the Frequency Counter to obtain the output frequency.

If the Frequency Counter does not indicate 60.000 ±0.0006 Hz, adjust C43 for the correct frequency. Refer to Figure 4-2 for the location of C43.

4.6.2 VOLTAGE GAIN ADJUSTMENT

The voltage gain adjustment must be made with the top cover removed.

To adjust the voltage gain perform the following steps.

1. Remove the Voltage Sense wires from the voltage output terminals.

2. Remove all loads from the voltage output terminal and connect an AC DVM to the output.

Figure 4-2 Internal Adjustments and Jumper Locations.

Figure 4-3 Current and Voltage Gain Adjustment

3. Program the output to 60 Hz and 200 volts. Keep the ENT key depressed to prevent the output from defaulting.

4. Adjust A9R109 (Refer to Figure 4-2) for an output of 220.0 ±1 VRMS.

5. Release the ENT key to allow the output voltage to default.

6. Repeat steps 1 through 5 for phase B and C of a 3-phase test system if applicable.

4.6.3 CURRENT GAIN ADJUSTMENT

The current gain adjustment must be made with the top cover removed. The current gain adjustment must be made under full-load conditions. Refer to Figure 4-2 for the location of the 200 AMP and 20 AMP GAIN adjustments. Refer to Figure 4-3 for the equipment hookup for the adjustment. Perform the following steps:

1. Program the output to 200 amps and 60 Hz. Adjust the load for 7.5 volts across the output terminals.

2. Press and hold the ENT key. Short TP2 to TP1 on the current Limit Board (A9).

3. Adjust the 200 AMP GAIN adjustment for 210 amps.

4. Release the ENT key and remove the short to TP2.

5. Connect the 1.25 ohm load to the 20 amp output. Program the output to 20 amps.

6. Press and hold the ENT key. Short TP3 to TP1.

7. Adjust the 20 AMP GAIN adjustment to 21.0 amps.

8. Release the ENT key and remove the short from TP3 to TP1.

9. Replace the top cover and repeat steps 1 through 8 for the phase B and C power source if applicable.

4.6.4 PHASE ANGLE CALIBRATION

4.6.4.1 CALIBRATION OF CURRENT TO VOLTAGE OUTPUT PHASE ANGLE

1. Connect the test equipment as shown in Figure 4-4. Start with the Phase Meter B input connected to the 200 Amp Current Transformer (.01V/A).

2. Program the voltage to 120 volts, the current to 200 amps and the current phase angle to 0.0 degrees. For a Phase A power source, program the frequency to 60 Hz.

Figure 4-4 Phase Angle Calibration

3. Check the phase angle. If the phase angle is within ±0.5° of the program value, go to step 10. Perform steps 4 through 9 to calibrate the phase angle if the deviation is more than ±0.5° from the program value.

4. Access the phase screen with the key sequence:

   7 ENT

5. Depress the MNU key several times until the following screen is displayed:

   *   CLK = 02   CUR = 04

6. Enter the key sequence: 959 ENT

7. Depress the MNU key several times until the Configuration menu screen is displayed:

   CFG = 16 LMT = 17
   FLM = 18 CLM = 19

8. To display the POF screen enter the key sequence: 20 ENT

9. To calibrate the Current Phase angle, press the C key. Program the correct phase offset value. Remember that a negative value is entered by depressing the period key (.) once or twice after the numeric value.

10. Connect the Phase Meter B input to the 20 amp current transformer (.1v/amp). Refer to Figure 4-4. Program the output to 20 amps. Perform steps 3 through 9.

11. Connect the Phase Meter B input to a 0.5 ohm, 5 watt resistor that is in series with the 20 amp output. Program the output to 2.0 amps. Perform steps 3 through 9,

4.6.4.2 CALIBRATION OF VOLTAGE TO VOLTAGE OUTPUT PHASE ANGLE (Phase B and C sources only)

The following procedure requires at least two 4500FX power sources.

1. Connect the test equipment as shown in Figure 4-4 except connect the voltage output of the Phase A source to the A input of the Phase Meter. Connect the voltage output of the Phase B or C source to the B input of the Phase Meter.

2. Program the Phase A voltage output to 120.0 volts and 60 Hz. Program the Phase B or C voltage source to CLK EXT and the voltage to 120.0 volts. Program Phase B to 240° and Phase C

to 120°.

NOTE (*): Shown only on Phase B and C Power Source.

3. Check the phase angle. If the phase angle varies by more than ±0.5° from the programmed value, perform steps 4 through 8 of paragraph 4.6.4.1. and continue with the following step.

4. To calibrate the voltage phase angle, press the A key. Program the offset value.

4.6.5 CURRENT LIMIT CALIBRATION

1. Select the Current Limit (CRL) screen (Screen 8) and program the Current Limit value of 4.0 amps.

2. Monitor the output current from the voltage OUTPUT terminals with the external current transformer and AC DVM. Connect an oscilloscope to the output.

3. Program the output voltage 190 volts, 60 Hz.

4. Apply a 48.6 ohm/1500 watt load to the voltage output only. (Apply a 64.9 ohm/1500 watt load when the 312 volt range, HV Option, is installed).

5. Increase the output amplitude slowly until the external AC current transformer indicates 4.28 amps. Slowly turn A9-R17 on the Current Limit Assembly in a counterclockwise direction until the output just starts to clip.

   Slowly readjust R17 in a clockwise direction just to a point where the clipping disappears.

6. For a 3-phase test system repeat steps 1 through 5 for the Phase B and C power sources.

SECTION 5

THEORY OF OPERATION

5.1 GENERAL

An explanation of the circuits within the AC Power Test System is given in this section. Refer to Figure 5-1 for a block diagram of the AC Power Test System.

5.2 OVERALL DESCRIPTION

Input power from the rear panel is routed through the circuit breaker to the Input Power Supply (A5). DC voltages from the Input Power Supply are routed to the Power Mother Board (A4), the Control Mother Board (A8) and the Auxiliary Power Supply (A7).

The Programmable Oscillator assembly (A11) generates the oscillator waveforms and power source control and measurement signals. The oscillator assembly is connected to the rest of the power source through the Control Mother Board, A10.

The three amplifier modules are A1, A2 and A3. They take their DC supply voltages and input signal from the Power Mother Board, A4. They produce the high power outputs for the primary of the output transformers, T1, T2 and T3. The outputs are routed through the Power Mother Board to the output transformers.

The Range Relay Board is identified as A6. This board assembly configures the secondaries of the output transformers for the correct output voltage range. The outputs from the AC Power Test System are taken from the Range Relay Board. This board also has relays that switches the output to the 1-phase mode and opens the outputs. There is also a circuit on the board that senses for incorrect sense line connections.

The board assemblies are described in more detail in the following paragraphs.

5.3 INPUT POWER SUPPLY

This assembly is identified as A5. It generates the high power +300 VDC supply. This supply voltage is connected to the filter capacitor, C1, and to the Power Mother Board. C1 is mounted on the bottom cover of the AC Power Source.

The Input Power Supply also has circuits that generate the DC voltages identified as ±18V, ±15VSW, and +8V.

The ±18V supplies are used for the Oscillator Module and the

Current Limit Board. The +8V supply is used for the Oscillator Module. The ±15VSW supplies are used for the three Amplifier Modules.

Figure 5-1 AC Power System Block Diagram

5.4 AUXILIARY POWER SUPPLY

The Auxiliary Power Supply receives the +300 supply voltage from the Input Power Supply. The +300 supply voltage is then changed to the +50 VDC supply voltage for operating the fans and relays. In addition to the +50 VDC supply, +15VSW1 is also generated. This supply voltage is used for the gate drive signal in the Amplifier Modules.

5.5 CURRENT LIMIT BOARD

The Current Limit Board receives the oscillator signals identified as OSC A, B and C from the Oscillator Module. Analog switches on this board direct the oscillator signals to the respective amplifier module. The analog switches switch the OSC A signal to the voltage amplifier, the OSC B signal to the 200 AMP amplifier and the OSC C signal to the 4/20 AMP amplifier. A gain adjustment is on this board to adjust the gain of the voltage amplifier channel.

The current limit circuit is also located on the Current Limit Board. This circuit receives a DC signal form the Oscillator Module, CLA, that is proportional to the current limit value. This DC signal is compared to the output current. The output current signal is identified as TA. This signal is routed to the Current Limit Board from current transformers on the Range Relay Board. If the output current exceeds the programmed value, an attenuator will limit the output voltage to a value that will cause the AC Power Test System to operate at a constant current. If the output current limits the output voltage to 10% of the programmed voltage amplitude value, the output will default and a VLT FAULT error message will be displayed. The error message will also be reported through the IEEE-488 (GPIB) interface.

The Current Limit Board has analog switches and summing amplifiers that are used for current measurements. The outputs from the summing amplifiers, CT B and C, are routed to the Oscillator Module for measurement.

5.6 INDICATOR BOARD

The Indicator Board has the reference designator, A12. This board has LED indicators for the OVERTEMP and OVERLOAD conditions.

A front panel selector switch is mounted on the Indicator Board. This switch is used to connect the front panel analog meter, M1, to either the phase A, B or C output.

5.7 RANGE RELAY BOARD

The Range Relay board has all of the AC Power Source relays. The relays are operated from +50 VDC.

One relay is used to switch the output current range between 20 and 2 amps. The other relays short the current output after an open circuit condition is detected.

A current transformer on the Range Relay board monitors the output current for the 20 and 2 amp range. The signal from the current transformer is used for current feedback and for measurements.

5.8 AMPLIFIER MODULES

The AC Power Test System has three Amplifier Modules. There is one voltage and 2 current amplifiers.

The Amplifier Modules operate in a switch mode to obtain high efficiency. These switch mode amplifiers operate at 200 KHz.

Each Amplifier Module obtains its input signal from the Current Limit Board. These three input signals are identified asø A SIG,ø B SIG andø C SIG. A 5.00 VRMS input signal will generate a full scale output voltage or current at the output of the AC Power Test System with 100.0 VRMS on the primary of the output transformer at full load.

Each Amplifier Module requires +300 DC, ±15 VSW, and the +15 VSW1 supplies. The +300 VDC supply comes from the Input Power Supply through a 15 amp fuse on the Power Mother Board.

The Amplifier Module has a thermoswitch mounted on its heatsink. If the heatsink temperature reaches 100°C, a control signal is sent to the Oscillator Module. A logic low on the **Error! Objects cannot be created from editing field codes.**1 control line will cause the error message TEMP FAULT to be generated.

5.9 OSCILLATOR MODULE

The Oscillator Module is identified with the reference designator, A11. The module consists of three printed circuit assemblies. These three assemblies are interconnected with a small mother board, A11A2. The oscillator Display Assembly connects to the

Oscillator Module with a short ribbon cable. The Display Assembly is mounted on the front panel. The block diagram of the Oscillator Module is shown in Figure 5-2.

Figure 5-2 Oscillator Module Block Diagram

5.10 CPU/GPIB BOARD

The CPU/GPIB board, A11A3, provides the control and measurement functions of the module. A microprocessor circuit accepts commands from the GPIB on the front panel keyboard. It sends digital programming information to set the output parameters of the power source. Data from measurement circuits are accepted and reported to the display and GPIB. Measurement calibration coefficients are stored in a memory backed up by a battery. The battery has a 10 year life expectancy.

Measurement circuits on the CPU/GPIB board monitor voltage, current, power, frequency, and phase angle. Voltage from the rear panel sense connector is scaled, converted to a DC voltage by a true-rms-converter, and sent to the microprocessor by the analog-to-digital converter.

Current sensed by internal current transformers is scaled, converted to a DC voltage by a true-rms-converter, and sent to the microprocessor by the analog-to-digital converter.

The scaled voltage and current waveforms are applied to the inputs of a multiplier. The multiplier output is filtered to a DC level and digitized by the analog-to-digital converter.

Frequency is computed from the measured time intervals between zero crossings of the Phase A waveform. Phase is computed from the differences of measured zero crossings between the Phase A signal and the Phase B or Phase C signal.

A digital-to-analog converter on the CPU/GPIB board sets the DC voltages that are used for the programmable current limit function.

5.11 PHASE A/REF BOARD

The Phase A/Ref Board, A11A5, serves several purposes. A programmable clock sets the output frequency of the power source. Digital-to-analog converters program references to set the output amplitude of Phases A, B and C. A sine wave generator creates a 1024 step waveform which is filtered to provide the Phase A oscillator signal for the voltage output. The Phase B sine wave generator is for the 200 Amp output and the Phase C generator is for the 20 and 2 Amp output. An external sense amplifier controls the voltage output amplitude.

5.12 PHASE B/C BOARD

The Phase B/C Board, A11A4, uses the DC voltage references and programmable clock from the Phase A/Ref board to generate the

Phase B and C oscillator waveforms. The Phase B signal is used for the 200 amp output. The Phase C signal is used for the 20 and 2 amp current output. External sense circuits control the Phase B and C output amplitudes.

5.13 DISPLAY MODULE

The Display Board, A11A13, is held to the power source by a small panel and is connected through a short ribbon cable. It holds the 20 button keyboard and a 32 character LCD display. A knob on the board allows the display viewing angle to be adjusted.

SECTION 6

MAINTENANCE AND TROUBLESHOOTING

6.1 GENERAL

This section describes the suggested maintenance and troubleshooting procedures. Table 6-1 lists the paragraph titles and page numbers for the Troubleshooting section. If the AC Power Test System does not appear to function normally, use this section to isolate the problem. If the problem cannot be found using these steps, consult the factory.

TABLE 6-1

6.2 POOR VOLTAGE/CURRENT OUTPUT ACCURACY

If the power source exhibits poor programmed output accuracy, the following item may be at fault:

1. The calibration is incorrect.

   SOLUTION: Calibrate the output. Refer to Paragraph 4.3.1 for voltage and paragraph 4.3.3 for current.

6.3 POOR OUTPUT VOLTAGE REGULATION

If the AC Power Test System exhibits poor voltage regulation the following item may be at fault:

1. The External Sense lines are not connected at the same point monitored by the external voltmeter used for load regulation

check.

SOLUTION: Connect AC voltmeter to External Sense lines.

6.4 OVERTEMPERATURE LAMP ON

If the power source OVERTEMP lamp is on, the following may be at fault:

1. Ambient temperature is too high.

   SOLUTION: Operate power source between 0 and 35° C.

2. Fan or ventilation holes are blocked.

   SOLUTION: Remove obstructions.

3. Fan not working.

   SOLUTION: Replace fan. Consult factory.

6.5 OVERLOAD LAMP ON

The OVERLOAD lamp comes on when the load current on the voltage output has exceeded the programmed current limit value. If the AC Power Test System OVERLOAD lamp is on, the following items may be at fault:

1. The output is overloaded.

   SOLUTION: Remove the overload.

2. The programmable current limit level is set too low for the load being driven.

   SOLUTION: Compute and reprogram the correct programmable current limit level.

3. The programmable current limit is incorrectly calibrated.

   SOLUTION: Perform the calibration in paragraph 4.6.5.

6.6 CAN'T PROGRAM AC POWER TEST SYSTEM ON GPIB

If the power source does not respond to IEEE-488 GPIB programming, the following items may be at fault:

1. The power source unit address is wrong.

   SOLUTION: Update address. See paragraph 3.7.1.

2. GPIB cable is loose at power source rear panel.

   SOLUTION: Check connection, tighten jack screws.

3. The oscillator has failed.

   SOLUTION: Replace the oscillator. See Paragraph 6.10.

6.7 DISTORTED OUTPUT

The AC Power Test System output may have a distorted sine wave from the following causes:

1. The power source voltage output is overloaded.

   SOLUTION: Remove the overload or program the current limit to a higher value. Observe power source capabilities. See Section 1.

2. The crest factor of the load current exceeds 2.5.

   SOLUTION: Reduce the load.

3. The 200 Amp output may have a distorted current output if the offset adjustment is in need of adjustment.

   SOLUTION: Connect the 200 amp load to the 200 amp output. Monitor the output current waveform with a Current Transformer. Connect the Current Transformer secondary to the distortion analyzer. The distortion analyzer must be HP339A or equivalent. Program 200.0 amps and adjust the load for 7.5 volts on the Output Bus Bars.

   Adjust the DISTORTION ADJ for the 200 AMP CURRENT AMPLIFIER (refer to Figure 4-2) for the lowest distortion on the distortion analyzer. The 80 KHz filter must be enabled on the distortion analyzer.

4. The 20 amp output may have a distorted current output if the offset adjustment for the 20 AMP AMPLIFIER needs to be adjusted.

   SOLUTION: Connect a 1.25 ohm load with a current transformer to the 20 amp output. Monitor the current transformer output with the distortion analyzer. Program 20 amps and adjust the 20 AMP CURRENT AMPLIFIER DISTORTION ADJ for the lowest distortion.

6.8 NO OUTPUT

If the AC Power Test System has no output at the rear panel terminal block, TB1, the following items may be at fault:

1. If the External Sense lines are not connected correctly, there will be no output. The error message VLT FAULT will also be generated.

   SOLUTION: Correctly connect the sense lines. Refer to Paragraph 2.5.

2. When the voltage output is overloaded an error message will be generated and the output relays will open. The error message would be VLT FAULT.

   SOLUTION: Remove the overload. Observe the output power capabilities. Refer to Section 1.

3. There is no input to the power amplifiers from the oscillator. Check the oscillator signals at the system interface connector:

   J7-24 Oscillator Phase A
   J7-6 Oscillator 200 Amp
   J7-23 Oscillator 20 Amp
   J7-7 Oscillator common/return

   Program 270 volts. the signal at J7-24 should be 5.0 ±0.10 VAC. If will be necessary to hold the ENT key depressed to keep the oscillator from faulting.

   SOLUTION: If there is no signal at the Systems Interface connector replace the oscillator. Refer to paragraph 6.9.

   SOLUTION: If the signal at the System Interface connector is greater than 5.0 VAC, it may be necessary to replace the voltage amplifier. Refer to paragraph 6.11.

   Program 200 amps. The signal at J7-6 should be 5.0V rms.

   SOLUTION: If there is no signal at the Systems Interface connector, replace the oscillator. If the signal is greater than 5.0V rms replace the 200 AMP AMPLIFIER.

   Program 20 amps. The signal at J7-23 should be 1.7V rms.

   SOLUTION: If there is no signal at the connector, replace the oscillator. If the signal is greater than 1.7V rms,

replace the 20 AMP AMPLIFIER.

4. One of the internal fuses, F1, F2 or F3 has failed.

   SOLUTION: Replace the fuse. Remove the input power and discharge capacitor C1 before replacing the fuse. Refer to paragraph 6.11.

6.9 MODULE REMOVAL

Figure 6-1 shows the location of the internal modules and assemblies. The figure shows the Amplifier Modules, A1, A2 and A3, with the insulator removed. A1 is the Voltage Amplifier, A2 is the 200 Amp Current Amplifier and A3 is the 20 Amp Current Amplifier.

6.10 OSCILLATOR MODULE REMOVAL/REPLACEMENT

If a fault is found that requires the replacement of the Oscillator Module (assembly 3009-402) perform the following steps and refer to Figure 6-1 for the module locations:

1. Turn off the front panel circuit breaker.

2. Remove the power system's top cover.

3. Remove the Keyboard/Display assembly by loosening the two captive screws on its front panel.

4. Unplug the ribbon cable from the Keyboard/Display assembly.

5. Remove the Oscillator Module, A11, by pulling up the package of PC assemblies.

6. The module is now removed. To replace the module follow these steps in reverse order. Make sure the ribbon cable that plugs into the Keyboard/Display assembly runs between PC assembly, A11, and the front panel.

6.11 AMPLIFIER REMOVAL/REPLACEMENT

A VLT FAULT error message indicates a problem exists with the voltage output. If there is no voltage output and there is an oscillator signal at J7, pin 24, check the condition of fuse F1. Disconnect the power source from the input power line before testing any fuse.

CAUTION

> Capacitor C1 may have up to +350 VDC after the input circuit breaker has been turned off. Before inspecting fuses F1, F2 and F3, discharge C1. C1 may be discharged through a 5 ohm power resistor.

If F1 is blown replace the fuse and apply power to the power source. If the fuse blows again replace Amplifier A1.

A CUR FAULT error message indicates a problem exists with the current output. For a programmed current between 20.1 and 200.0 amps, the oscillator signal output is J7, pin 6. the current amplifier is A2. If there is no output current and there is an oscillator signal, check the condition of fuse F2. If the fuse is open replace the fuse, apply power and reprogram the output. If the fuse fails replace amplifier A2.

For a program value from 0.02 to 20.00 amps the oscillator output is available on J7, pin 23. The current amplifier is A3 and the fuse is F3.

If it is determined that an amplifier module must be replaced, perform the following procedures:

1. Turn off the input circuit breaker.

2. Remove the AC Power Source top cover.

3. Remove the four #6 screws that hold the insulator that covers the amplifier module, A1, A2 and A3.

4. Remove any of the three amplifiers by sliding it up and over the guide posts.

5. The amplifier may be replaced by following this procedure in reverse order.

6. Check the amplifiers associated 15 amp fuse and replace it if necessary. Refer to Figure 6-1 for the location of the fuse. F1, F2 and F3 are for A1, A2 and A3 amplifiers respectively.

Figure 6-1 Module Location

SECTION 7

REPLACEABLE PARTS

7.1 GENERAL

This section contains ordering information and a complete list of replaceable parts. The parts are listed by their major assembly in alpha-numeric order by their reference designators. The list includes the parts description, manufacturers' identification (see Appendix A for list of manufacturers), and California Instruments' part numbers.

7.2 ORDERING INFORMATION

In order to ensure prompt, accurate service, please provide the following information, when applicable, for each replacement part ordered.

a. Model number and serial number of the instrument.

b. California Instruments part number for the subassembly where component is located (PARENT ITEM NO.).

c. Component reference designator (SEQ NO.).

d. Component description (DESCRIPTION TRUNCATED).

e. Component manufacturer's FSCM number (VENDOR).

f. California Instruments part number (COMPONENT ITEM NO.).

All replacement part orders should be addressed to:

California Instruments
Attention: Parts Department
9025 Balboa Avenue
San Diego, California 92123-1509

TOP ASSEMBLY REPLACEABLE PARTS
FOR 4500FX
TOP ASSEMBLY NO: 3009-400-2

SEQ NO.	COMPONENT ITEM NO.	DESCRIPTION	VENDOR	QTY
A1	4009-423-1	HEATSINK ASSY, SW AMP	16067	1.0
A2	3009-401-2	HEATSINK ASSY, SW AMP	16067	1.0
A3	3009-401-1	HEATSINK ASSY, SW AMP	16067	1.0
A4	4009-724-1	PC ASSY, MOTHER	16067	1.0
A5	4009-706-1	PC ASSY, POWER SUPPLY	16067	1.0
A6	3009-700-2	PC ASSY, RANGE	16067	1.0
A7	4009-735-1	PC ASSY, AUX POWER SUPPLY	16067	1.0
A8	4009-732-1	PC ASSY, MOTHER, CTRL	16067	1.0
A9	4009-728-3	PC ASSY, CURRENT LIMIT	16067	1.0
A11	3009-402-2	MODULE ASSY, OSC	16067	1.0
A12	4009-707-1	PC ASSY, INDICATOR	16067	1.0
B1	241178	FAN, 6", 48VDC, .45A	63227	1.0
B2	241175	FAN, 4", 48VDC,	23936	1.0
C1	611295	CAP, AL, 3900ìF, 400V	80031	1.0
F1	270167	FUSE, 15A, 250V	71400	1.0
F2	270167	FUSE, 15A, 250V	71400	1.0
F3	270167	FUSE, 15A, 250V	71400	1.0